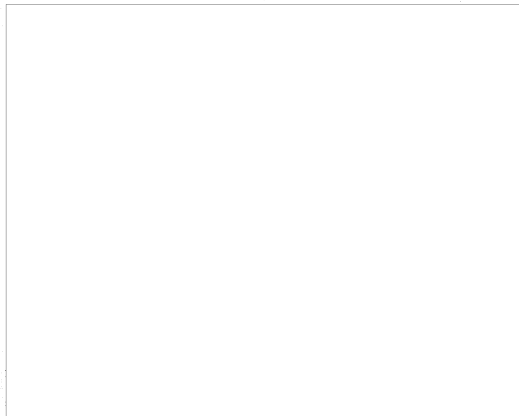


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An Attempt at Industrial Agriculture in
Climate Regions in Poland

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AN APPROPRIATE APPORTIONMENT AGRICULTURAL-CLIMATIC REGIONS IN POLAND

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Before beginning to characterize the agricultural-climatic regions, which I have provisionally established for the territory of the Polish Republic within its contemporary boundaries, I should perhaps first devote a few words to a discussion of the principle and of the criteria which I used for the conducted apportionment.

The methods of modern dynamic climatology, unfortunately, have not been investigated sufficiently in order to use only them in a climatic-region apportionment of this type. It is difficult to agree with Merecki, who is considered the precursor of this trend in Polish climatology, that a climatic region consists of "that area of the country in which the same type of weather prevails on the average." (See R. Merecki, Klimatologia Ziemi Polskiej [Climatology of Polish Lands] Warsaw: 1915, page 26). This principle is correct and rational with regard to stu-

dies of climate from the point of view of the latter's ge-
 nesis and structure. It is not always acceptable for app-
 lied purposes. At any rate, the principle can not be used
 in the case of establishing agricultural-climatic regions.
 "It is a matter of indifference," states Kerecki, "that the
~~the fact becomes~~ average monthly temperature on the Hel peninsula is $\pm 0.3^{\circ}$
~~degrees, 1~~; and in Wilno -3.6° ~~degrees, 1~~; and in Warsaw -2.3°
~~degrees, 1~~, providing that these three localities belong
 to the same climatic field. If such is the case, we can
 have quite an accurate idea of the course that certain fac-
 tors will take in the other localities, on the basis of the
 course of these same factors in Warsaw."

Undoubtedly all three of these localities can be
 considered as being in the same climatic zone, taking into
 account that the same type of weather prevails. They can
 not, however, be incorporated in the same climatic region,
 at least not in the same agricultural-climatic region, be-
 cause they lie in completely different areas from the point
 of view of the disposition of meteorological elements most
 important for agricultural production; they also lie in
 absolutely different zones of this production.

Apportionment of agricultural-climatic regions
 should be based upon the disposition of the most characte-
 ristic, from the agricultural point of view, climatic in-
 dexes; this disposition should be implicit in the very
 division of climates. The disposition should cover, to a
 considerable degree, the separate climatic ^{sub-regions} ~~regions~~ so
 that we can be relieved of "computing" the meteorological
 conditions of one locality on the basis of the meteorolo-

gical conditions in another locality.

Unfortunately, the principle of division - these 1 leading agricultural-climatic indexes - is a problem that has not been solved up to now. Different authors apply different criteria here, similarly to authors classifying climates on a world-wide scale who also apply varying principles of division. This problem will not be solved by climatologists alone, without the participation of farmers. Unfortunately, farmers do not all hold the same opinion in this matter.

My concept of dividing Poland into agricultural-climatic regions, expounded below, does not contain in the least and can not contain a definitive solution for the establishment of agricultural-climatic regions on the territory of our country. The reason for this is perhaps primarily the subjectivity by which the principles for division were selected. This subjectivity was simply caused by the quality and span of meteorological observation materials at my disposal. The situation in Poland, from this point of view, is not too satisfactory. Not all climatic elements have been investigated and written up in monographs. The existing monographs are based on a series from the period 1881-1910 (25 years), a series quite far back ~~which does not encompass the last 40 years.~~ It is, let us say "obsolete," if only in view of the fact that the network of meteorological stations has considerably expanded during the last 40 years. Therefore, a picture

of the space disposition of the individual climatic elements on more modern material, that is on a denser net and on a longer series, may differ from a picture based on a less dense net and a shorter series. One could give several examples here by comparing, for instance, an annual map showing the precipitation in Poland based on the period 1891-1910 with a map of annual precipitation issued not long ago by the "Reichsamt für Wetterdienst" (German International Weather-Service Bureau), partly encompassing the territory of Poland and based on the period 1891-1930.

The many intervals and gaps in observations, the lack of continuity in the work of many meteorological stations, the non-uniformness of materials - are all reasons for which the writing up of monographs on the individual climatic elements for longer periods and brought up to the most recent years would necessitate a considerable output of work and a long time. The time would be even longer, providing that we want to compute the climatic indexes with reference to the units of time corresponding to the basic life phases of the most important, from the agricultural point of view, cultivated plants - and not with reference to traditional calendar units.

Therefore, exhaustive monographic reports, consisting of valuable contributions to the establishment of agricultural-climatic regions in Poland, will not appear in the near future. Encouraged by the Main Office for Space Planning, I decided upon conducting an attempt to apportion such

regions on the basis of such materials as I had at my disposal or which could be worked out in a relatively short period of time. My task was made at least a little easier by the fact that I had worked out during the German occupation a disposition of average monthly and yearly values for the temperature of the air as well as for monthly and yearly totals of atmospheric precipitation (together with W. Iyszkowski) in the central and eastern areas of Poland. This project was conducted by the same methods and for the same periods of time as the basic German project, the results of which are given in Klimakunde des Deutschen Reiches (Climatic Knowledge of the German Republic), published by the German "Reichsamt für Wetterdienst" (National Weather-Service Bureau). After being supplemented, it -together with data from the Klimakunde- was the initial basic material for establishing climatic regions. (Not only all material printed in the yearbooks but also all materials from archives were utilized for this project; they underwent minute qualitative analysis, with special attention that the material be uniform.)

So, I had at my disposal the average values from such two basic elements of climate as air temperature and precipitation totals. These had been worked out with the necessary accuracy over a suitably long period of time, ending in 1930. I was compelled to take other elements either from older series or from series differing with regard to time units as well as time lengths. As a result, I was forced

in many cases to give up attempts at synchronizing the material or making it uniform from the scientific and comparative points of view. But since I tried to take into consideration as many of these elements as possible, I had a basis for my thesis that these anomalies in the disposition of the phenomena, to which - if not all then - at least a majority of these elements point, truly correspond to reality.

I further took the approach that, with regard to the transfer of our national economy to a planned economy, the matter of establishing agricultural-climatic regions has become timely and urgent. In view of this fact, it was better to make the attempt of ascertaining even less accurate agricultural-climatic regions on the basis of incomplete materials in my possession than to postpone this attempt until all the basic materials had been worked out - which would have meant a postponement into the indefinite future.

My concept has as its basis a model of climatic indexes which enter into the span of three basic factors, indispensable for the development of a plant:

- 1) heat.
- 2) water.
- 3) light.

.....
 TAT. Indexes characterizing the course of air temperature belong here. The initial materials were the aver-

are monthly and yearly values of temperature, computed from the period 1881-1930 (50 years) partly by the German "Reichsamt für Wetterdienst" (National Weather-Service Bureau) in Berlin, published in the above mentioned Klimakunde des Deutschen Reiches (the Recovered Territories, the Poznan area, Pomerania, Silesia). However, I did not consider these average values for monthly temperatures as representative from the agricultural point of view, and I did not base my work directly upon them. I utilized them only for computing the beginning of the curve for annual temperature over designated "thresholds" and the times during which average temperature continued above the given "threshold."

The following temperature indexes belong to those utilized by me:

1. Average annual minimums for daily (24 hours) temperatures. The corresponding data for the territories of western Poland, taken from Klimakunde, are computed from the period 1881-1930; data for the eastern parts of the country were computed by me from the period 1884-1941. The averages vacillate for the territory of Poland in the limits from over 5 degrees (at Swinoujscie) to ~~1.0~~ ^{1.0} in low country (Margrabowo) and below 0° ~~degrees~~ in the mountains (Zakopane 0° ~~degrees~~; Sniezka - 2.6° ~~degrees~~). The disposition of averages shows local influences.

2. The number of cool days during the year (minimum temperature < 0 degrees). Data for the western part of the country was computed from different periods which

were, however, within the span of the period 1881-1970. Data for the eastern part was computed partly from even longer periods (1881-1975) and also partly from considerably shorter periods - a series of up to 50 years. This is in contrast to the western areas, where the shorter periods were never smaller than several tens of years. The average values for cool days vacillate within the limits of from 80 to almost 150 in low country and to over 200 in the mountains. Local influences are obvious.

3. Average number of freezing days per year (maximum temperature ≤ 0 degrees). The periods are the same as for cool days. The average number of freezing days vacillates over the territory of the country from 25 to almost 70 in low country and to almost 140 in the mountains. Local influences are visible but to a smaller degree.

4. Average number of very freezing days per year (maximum temperature ≤ -10 degrees). Periods as for cool days. Average values ^{in the state} vacillate on the territory of Poland within limits from 0.5 (one very freezing day every two years) to 6 in low country and to over 10 in mountains (^{snowcaps} ~~on the~~ 17 days).

5. Average yearly maximums for daily (24 hours) temperature. Periods as for medium temperature minimums. Average values for the maximum temperature vacillate within limits from 13 degrees (vicinity of Tarnow) to 9 degrees in low country and to 3 degrees in mountains (^{snowcaps} ~~on the~~ 2.9 degrees).

6. Average number of summer days per year (maximum temperature $\gg 25$ degrees). Periods as for cool days. The average number of summer days vacillates within limits from 10 to 50 in low country. In the mountains, the average number is only a few (on ^{average} ~~on~~ 0).

7. Average number of hot days per year (maximum temperature $\gg 30$ degrees). Periods as for cool days. The number of hot days vacillates within limits between 1 and 7.

I drew maps for all of these indexes. However, due to the small quantity of observational material concerning extreme temperatures - which as a rule have greater gaps than material covering current temperatures; - due to the non-uniformness of the material; and also because of the strong influence upon extreme temperatures and local conditions, all curves drawn on these maps - even though they have been constructed in accordance with the generally accepted principles - can not be considered as isarithms in the precise meaning of this term. They only provide us with a general spatial disposition of the given element; they are not so much lines connecting points that have the same values for a given factor as they are lines delimiting areas on which the value of a given element vacillates within certain defined borders.

The following two still belong to the number of thermic elements utilized by me:

8. Disposition of spring frosts. Basis: material from the period 1881-1930 for western areas (west of the

border of Iceland in 1939), which material already computed was taken from Klimakunda: for eastern areas. I computed the average and the extreme data for frosts in the period 1924-1935. The averages from both periods differ very little (1. at the most 2 days), and they can therefore be considered comparable.

The average dates for the last spring frosts vacillate on the territory of Iceland within limits from the middle of April in general to the end of the first ten days in May, with regard to low country areas. In the mountains, frosts can take place on the average during all of May and even in June (on ~~June 10~~, the last frost falls on the average on June 10). The area of Imeraria, in the vicinity of Leborg and Toraj, draws attention by the extraordinarily late days for its last frosts. In Leborg, the average day for the last frost falls on May 15x; in Toraj, on June 1. This probably has some connection with the local characteristics of these areas, among other things with the peat-like soil which is a poor conductor of heat.

9. Anomalies of temperature. The average value for air temperature is a function of the geographic location (φ , λ) and the altitude above sea level (h). Apart from these, influence is also exerted by the regional (r) and local (l) factors. All of this can be portrayed in the following relationship: (see A. Gregor, Tepelné Pomery Cechoslovenska Heat Measurements in Czechoslovakia, Prague, 1929.)

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$T = (\varphi, \lambda) \neq (v) \neq (r \neq l \neq b) = (\varphi, \lambda) \neq (v) \neq D$
 where "D" is the composite, resulting from an inappropriate
 connection of unhomogeneous observational series, errors
 in computations, etc. Beginning from this basis, I drew a
 map of temperature anomalies in the following way: From
 Guttler's tables, I interpolated the theoretical value of
 the average temperature for each station, corresponding to
 its geographic coordinates. I compared the actual average
 values, after reducing them to sea level (using the gradient
 of 1 degree, 5/100 meters), with the foregoing value. I trans-
 ferred the difference D under the appropriate stations on
 the map. The areas, on which the differences rose to above
 ± 0.4 degrees, ± 1 considered as areas having a positive $\pm$
 thermic anomaly; whereas areas in which these differences
 fell below -0.4 ~~degrees~~ were considered as areas posses-
 sing a negative thermic anomaly. I looked upon differences
 within limits from $+0.4$ ~~degrees~~ to -0.4 ~~degrees~~, as be-
 ing normal: those with D from 0 ~~degrees~~ to $+0.4$ ~~degrees~~
 were considered as having a tendency toward a positive ano-
 maly, while those with D from 0 ~~degrees~~ to -0.4 ~~degrees~~
 were considered as having a tendency toward a negative ano-
 maly.

WATER. The following indexes served me to character-
 ize this factor:

10. Yearly total for precipitation. I based my
 work here on the precipitation material that was uniformly
 applied for the period 1891-1930: on a map for annual pre-

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precipitation worked out by myself and W. Lysakowski, a map for precipitation in northern Poland drawn by the German "Reichsamt für Wetterdienst" (National Weather-Service Bureau) expressly for the "Oberfinanzbezirk" (superior finance district) Danzig, and on the map for precipitation for the eastern parts of the former German State worked out by this same institution.

11. Average number of days with precipitation 70.1 millimeters. I utilized here material from the monograph on precipitation in Poland, worked out by S. Lisowski-Borucki. Although this monograph is based upon a different period (1891-1915), comparisons showed that the numbers from both periods do not differ very much among one another and that they can be considered as comparable.

12. Average number of days with snow fall. The western part of Poland, according to data from the period 1891-1920 from Klimakunde; the eastern part of Poland according to data from the textbook on climatology by Köppen-Geiger (a volume devoted to the climate of central Europe).

13. Commencement of snow cover. The western part of Poland, on the basis of the period 1901-1920; the central part according to data from the period 1892-1908; the eastern part from the period 1899-1912.

14. End of snow cover. Periods as in the preceding.

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15. Duration of snow cover in time. The western part of Poland according to data from the period 1901-1930, the central part according to the work of K. Chomicz (1930-1938) and also from the period 1899-1913. During the time I was in the process of doing my project, I received the excellent map of Doctor W. Wilata from which I profited especially for the southern part of Poland.

16. Average depth of snow. If we add up the depths of the snow cover, noted on individual days of the month

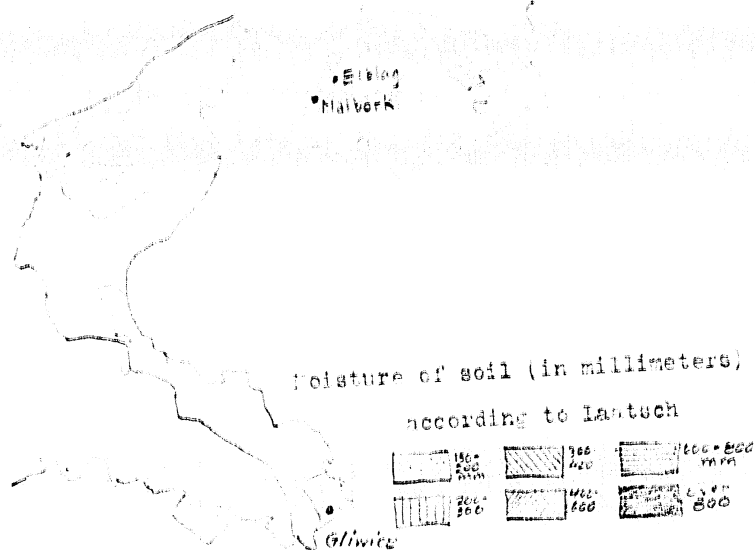


Figure 1. Disposition of moisture in soil

[Note: A comparison of the original of figure 1 on the last page]

and divide the total thus achieved by the number of days in the month, we obtain the so-called "average depth of snow" during that month. If, however, we divide that total by the number of days during which there actually was a snow cover, we obtain the so-called "average snow cover depth." For purposes of establishing regions, I utilized a map for the greatest diameter of snow depth. Periods: for western areas 1889-1907, according to the work of Stegers (H. Stegers, Beiträge zur Kenntnis der Dauer und Höhe der Schneedecke in Norddeutschland / Contributions to the knowledge of the Duration and Depth of Snow Cover in Northern Germany 7, 1918); for central areas 1892-1906; for eastern areas 1909-1913.

17. Time at which average depth of snow appears. Periods as above. This time occurs the later in proportion to the greater stability of the snow cover phenomenon and also in proportion to the larger depth attained by the cover.

Due to the lack of synchronization and the incomplete uniformness of the material concerning the snow and the snow cover, the same warning is appropriate with regard to the isorithms drawn on all above enumerated "snow" maps as the one expressed in the foregoing with respect to isorithms of temperature indexes. (nonetheless, German meteorologists accepted them as satisfactory for applied purposes and had them printed in the publication: Vergleich der Schneebeziehungen von Russland, Polen und Norddeutschland

[Comparison of the Snow Conditions in Russia, Poland and Northern Germany], Berlin: National Weather-Service Bureau, 1948).

The map, entitled "Fall of Hail in Poland," supplemented the series of index maps which entered into the period of atmospheric precipitation as a climatic element. Unfortunately, I worked out this map only on the basis of materials from the period 1930-1934. I based my work for this project on localities in which there had been noted, during the above 5 years, more than 1 days with fall of hail. The map shows hail paths with a general direction of SW - NE.

Sunshine. I took into consideration here: the average daily disposition of the number of hours having sun for the spring and summer. I took pertinent material from the book by Professor W. Gorczynski, entitled Comparison of the Climates of the United States and Europe (New York, 1945).

Among other climatic indexes, I took into consideration first of all the factor characterizing moisture relations. In our climatic treatises, the latter are usually omitted because of the monotony in the disposition of water steam elasticity and relative moisture on the territory of the country. These relations have first rate importance for establishing agricultural-climatic regions, because they provide an idea of how far the agriculture

is secure with regard to moisture - so needed for life. It is known that soil as well as plant life use up different quantities of water under various climatic conditions and especially at different temperatures.

After conducting several experiments, I discarded the idea of using various "coefficients" for this purpose (for example Lang's "rain" coefficient or Reich's coefficient of "dryness," because their construction is quite artificial and not based on physical relationships. They give a picture of spatial disposition which is not always in agreement with reality, although they do provide a certain general orientation. In my work, I based myself primarily on data from Laatsch concerning so-called "moisturization of soil" [Doctor Willy Laatsch, Die Durchfeuchtungsgrade der Deutschen Sandböden "Die Ernährung der Pflanze" - "The Moisturization Values of German Sandy Soil" "Nutrition of Plants," 1938. Doctor Willy Laatsch, Die klimatisch bedingten Durchfeuchtungsunterschiede der deutschen Böden - "The Climatically Conditioned Differences in the Moisturization of German ~~Soils~~ (7). He understands by this term the difference between the annual precipitation total and the annual evaporation. He designates the latter by adding up the average values for undersaturation of moisture and multiplying them by the "wind" coefficient and "soil" coefficient. Figure 1 shows the disposition of moisture for soils according to Laatsch. Unfortunately, this only applies to the Recovered Territories. Computation of "mois-

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tupizing" values for the rest of the Polish territory is a difficult undertaking and one that would consume a considerable amount of time. In order to attain at least a general conception concerning evaporation, I computed the values for the average undersaturation by moisture during the summer months (from May to July) in the 5 year period 1929-1933.

It is necessary to enumerate the following from the remaining indexes: length of vegetation period, phenological indexes (beginning of work in the fields, beginning of spring sowing of oats) and the frequency of strong winds in the winter and spring.

Under vegetation period, I understand the time of duration for average temperatures above a certain "threshold." Generally, a medium temperature of + 5 degrees or plus 10 degrees is considered as such a "threshold." I charted out isochronous lines for the "large" and "small" vegetation period. By "small" vegetation period, I mean that period, during which the average temperature does not fall below plus 5 degrees, °. By "large" period, I mean that period during which the average temperature did not fall lower than plus 5 degrees. I computed the dates for the crossing of curves for change in average temperature through the appropriate "thresholds," from average monthly values of temperatures (period 1881K-1930) according to the following formula:

$$A = 30 \frac{T - T_0}{W - T_0}$$

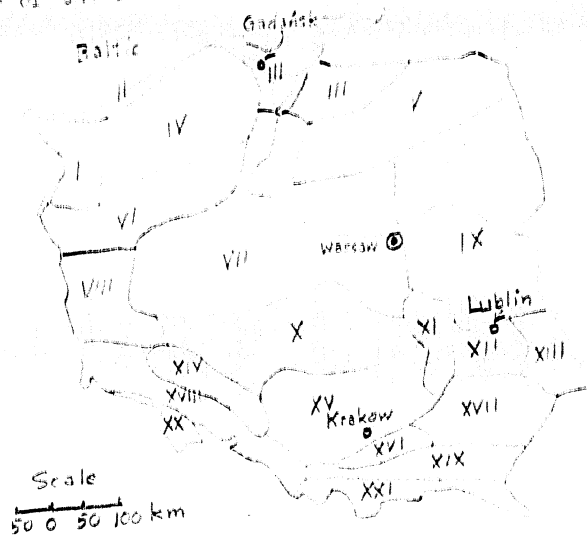
A designates the number of days, separating the middle day of the month which has a lower average monthly temperature with regard to the given "threshold" from the day on which the curve of the annual temperature course crosses the given "threshold." T designates the given "threshold" of temperature. M and N designate the closest maximum and minimum value of the average monthly temperature with regard to the "threshold" T. I computed the duration in time of the vegetation period, taking the length of all months as being 30 days.

I took the average temperature of plus 5 degrees, 5, basing myself on the investigations of Blackmann (I. E. X Blackmann, "The Influence of Temperature and Available Nitrogen Supply on the Growth of Pasture in the Spring," Journal of Agricultural Science, volume 20, number 4, 1930, pages 520-547) concerning the increase in meadow grasses in relation to temperature, and a "threshold" for computing the "small" vegetation period. Needless to say, the climatic conditions of England differ from our conditions. Basing myself on the investigations of Doctor P. Miklewski, which showed agreement between Blackmann's curve and a curve plotted for Poland, I accepted the temperature of plus 5 degrees, 5 as the above mentioned temperature "threshold." In any case, the selection of this or of another "threshold" is of no real significance for a consideration of the vegetation period duration as a criterion for the establishment of agricultural-climatic regions. The iso-

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withings for the duration of different periods, computed with relation to varying "thresholds" give a relative picture of the spatial disposition which is approximately the same. Areas, having a longer or shorter vegetation period, come out on every map in more or less the same place.

The beginning of work in the fields was worked out on the basis of observational material from the period 1930-1937. In general, meteorological conditions clearly influence the isochronous lines for the beginning of work in the fields. This is especially true for the time when the snow cover leaves the fields and for the air temperature. Some islands of land, where beginning of work in the fields is late, are caused - it would seem - by the influence of the following hydrological factor: the high state



R. Guminski: Attempt at Dividing Poland into Agricultural-Climate Regions (scale in kilometers)
 [to the original figure on the last page here]

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of soil waters, making for tardy drying up of the earth.

The beginning of spring oats sowing, which as is known takes place in early spring, was charted out on the basis of observational material from the period 1933-1939. Unfortunately, no map could be made for the south-eastern part of the country due to lack of material.

Wind belongs to agricultural-meteorological factors of considerable importance, especially during winter and spring. In the winter, strong winds bare the soil from its snow cover and can by this means cause a deeper freezing of the earth as well as related damage. In the spring, strong winds hasten the drying of the soil and, therefore, also the setting out of the farmer with his plow. I computed the percentage of strong winds during winter months (December-February) and spring months (March-May) for all stations in G. Bartnicki's monograph on winds in Poland and also for Białystok and Łódź, in order to characterize from this point of view the agricultural-meteorological regions established by me. I considered a strong wind to be one with a velocity of ≥ 5 meters per second.

Based myself on the above enumerated indexes, I segregated the territory of Poland into 21 agricultural-climatic regions. Their borders are shown on the attached map, and the following is an itemized breakdown:

Northern Zone

Regions:

- I Szczecin
- II Western Baltic
- III Eastern Baltic
- IV Pomerania
- V Mazury
- VI On Notec River
- .. VII Central
- VIII Western
- IX Eastern
- X Lodz
- XI Radom
- XII Lublin
- XIII Chelm

Central Zone

Regions:

- XIV Tereclaw
- XV Czestochowa-Tielce
- XVI Tarnow
- XVII Sandomierz-Leszow
- XVIII Sub-Budeten
- XIX Sub-Carpathian

Mountain Zone

- XX Sudeten
- XXI Carpathian

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"Genes" correspond here happily, in my opinion, with the climatological-synoptic fields established by Lorecki.

In certain cases, I gave priority either to thermic or to precipitation indexes, depending upon which values were more characteristic for the given territory from the point of view of needs in agricultural production. And so, for example, the salient points for apportioning the luxury region were thermic indexes, whereas precipitation indexes served mainly for establishing the Central region. In other cases, moisture of phenological indexes were decisive.

I attempted not to go into too much detail in the apportionment of regions, because our climate does not change suddenly in space but rather in a more or less constant way. For this reason, the climatic borders are only approximated. The more regions we were to differentiate, the more there would be boundaries, and thus the whole designation of regions would be less accurate. This is the more so in view of the fact that there exist besides macro-climatic differences also micro-climatic differences, often larger than the others. As an example, I wish to mention the locality of Zemborzyce near Lublin. The average annual temperature of Zemborzyce is 0 degrees, 4 lower than the average temperature at

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Lublin. The last spring frost comes on an average at Zemborzyce on April 27, whereas it comes on April 19 at Lublin which is one week earlier.. Other/in-^{thermic} dexes differ appropriately, and everything is caused by the local climatic influence of the moist valley of the Bystrzyca River at the bottom of which lies the locality of Zemborzyce.

I attempted to base my work of establishing the individual regions on actual observational material. I also tried to keep away from ideas based only on morphology of the territory, but at the same time realizing its incontestable influence upon climatic conditions. On the other hand, I willingly took into consideration the agricultural production zone in which the given area was located, soil conditions, as well as local conditions of production which were kindly reported to me by my colleagues - farmers, both scientists and practical farmers.

In ending, I should like to add that I conducted this whole investigation under contract with the Main Office for Spatial Planning, which office covered the cost of my work.

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Map of the Republic of Poland showing administrative districts (voivodeships) and major cities. The map is labeled with Roman numerals I through XXII. Major cities like Warszawa, Łódź, and Kraków are marked. A legend in the bottom left corner identifies the symbols used for voivodeships and cities.

Legend:

- Voivodeships (Województwa)
- Cities (Miasta)